SHARED AGENTS AND COMPETITION IN LABORATORY ENGLISH AUCTIONS

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At livestock auctions, the same purchasing agent can represent more than one processor. Repeated multiple-unit English auctions are created in a laboratory to measure the impact of shared agents on trade prices under alternative treatments with six, and as few as two, agents representing six principals. Treatments are constructed in which the agents either know or do not know quantity for sale, and in which there are progressively fewer agents bidding. Knowledge of quantity for sale can be anticompetitive. Evolution toward increased market concentration leads to consistent anticompetitive pricing, resulting in prices significantly lower than the predicted competitive equilibrium prices.

Key words: English auction, laboratory market, shared agents.

In 1998 approximately $16.5 billion of livestock was traded in the United States through registered firms selling on commission (United States Department of Agriculture 1998). Of this amount, 95% or $15.7 billion, was purchased by commissioned order buyers and dealers. There is a predominant use of dealers and commissioned order buyers in the livestock industries, both of whom may act as agents for multiple principals.[1] The use of shared agents by competing cull cow packer-principals has been a cause of concern for livestock sellers and auction market owners (United States Department of Agriculture 2001). Nearly all of the firms selling livestock operate sale barns, which commonly utilize the English auction trading method.

An English auction involves the auctioneer starting the bidding process at some predetermined price. This may be the reserve or no-sale price for the seller. If all buyers consider this price too high, they do not commence bidding. The auctioneer then decreases the initial starting price or takes the item "off the block." Once bidding begins, the bidding process becomes an ascending price auction. If the highest bid is not greater than the seller's reserve price, then the auction house may either purchase the item at a price that equals the seller's reserve price or the item is kept by the seller.[2] There is market pressure to sell, because the sale barn or livestock seller must incur storage and/or transportation costs, along with additional consignment fees if an animal is not sold. Moreover, the same buyers repeatedly attend the same livestock auctions and may not bid differently when these animals are auctioned at a later time.

English auctions are susceptible to buyer collusion (Milgrom). This results from the "open outcry" method of bidding. Buyers are able to acquire knowledge of rivals' bidding strategies and their reservation prices by directly observing their bidding; learning is particularly effective when there are few buyers

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This research was supported by the U.S. Department of Agriculture under cooperative agreement numbers USDAGIPSNC5418 and USDAG00-35400-9126. The findings and conclusions expressed in this article are those of the authors and do not necessarily reflect the views of the U.S. Department of Agriculture. Helpful comments from two anonymous journal reviewers are gratefully acknowledged.

[1] Order buyers purchase on a commission basis for others (principals) and by definition are agents. Independent dealers purchase livestock for resale on their own accounts. Dealers are agents only if the principal governs any of their actions. Beef processors typically make use of independent agent dealers, commissioned order buyers, and salaried buyers and manage the competitive relationships of all their agents. Commissioned order buyers and agent dealers, by the nature of their business, interact with multiple principals. The principals are commonly in competition with each other for raw products such as slaughter cows.

[2] Ashenfelter describes more elaborate practices for wine and art auctions. In these auctions the auctioneer may vary the start price and even begin below the reserve price. The auctioneer may announce fictitious bids to begin the real bidding. The "knock down" or sold item may truly be unsold if the bid price is below the reserve. Efforts are made to keep the reserve price secret. Ashenfelter recognizes that a likely purpose for the secrecy is to thwart the gains from a potential bidding ring.

Amer. J. Agr. Econ. 85(4) (November 2003): 829–839

in the repeated selling of items, as is the case for livestock auctions. There may be as few as two active buyers at some auctions, particularly when the buyers represent multiple principals. Repeated auctions attended by the same buyers also facilitate learning and cooperation. Again, the open outcry characteristic of natural English auctions allows for the monitoring and therefore the enforceability of a bidding ring as if it is a repeated game (Graham and Marshall). Ring members can punish the identified cheater. The punishment phase may keep the buyer from filling an order, or it could force the agent to bid higher. Thus, bidding rings may succeed by using a trigger strategy, and cooperation adjusts to the level allowed by a binding incentive constraint. Theoretical and empirical work on multiple unit auctions, the type common in agriculture and addressed in this study, is lacking (Klemperer). Specifically, additional attention should focus on identifying those factors that facilitate coordination between/among buyers in these auctions.

Product prices and processing costs, along with targeted profit margins, influence the development of what is called a buy-order in the beef industry.[3] The buy-order is given to buyers who are agents for the principal. The goal of these buyers is to purchase the live cattle for the minimum possible price. Accurate visual appraisal and low bidding may result in added bonuses for salaried buyers, increased order volume for commissioned order buyers, and increased profit margins for independent and agent dealers. There is intense pressure on agent buyers to meet the requirements of their principals. Buyers in competitive markets have an incentive to collude through a bidding ring in order to fill buy-orders at the lowest possible prices.

The multiple buy-order is a practice that allows competing principal firms to use the same buyer at auctions. The filling of multiple buy-orders by one agent arguably reduces the transaction costs of delivering cattle to processors. This practice, however, may put added monopsony power in the hands of the agent buyers. The use of shared agents increases market concentration at an auction and consequently increases the potential for coordination, not only among principals via their common agent, but also among the now fewer competing agents. This increased concentration potentially enhances the capability of agents to establish stable collusive arrangements in auctions. At least two studies provide evidence of the price-depressing effects of increased concentration in a single English auction market. Bailey, Brorsen, and Fawson investigated the influence of concentration in two large feeder cattle auctions and found evidence that increasing concentration depressed prices over time. Adam, Hudson, Leuthold, and Roberts in an experimental analysis report that prices can be depressed by buyers in a concentrated market, especially when there is a dominant buyer in an auction market.[4]

Market concentration alone, however, may not put market power in the hands of agent-buyers in these auctions. This is an empirical question. Two other features of the market also have the potential to foster the exercise of market power, resulting in depressed prices in a repeated English auction market. These are first, knowledge of the quantity of cattle for sale at an auction site. It is common practice of buyers to both inspect the quality of cattle and count them before the auction begins. And second, the history of the market as it moves toward greater concentration can create a familiarity among agents that promotes the exercise of monopsony power. It has not always been true that agents represented multiple packer-principals, and generally increased concentration in the cattle processing has led to the concentration of auction buyers. We demonstrate that the evolution toward concentration is an important determinant of behavior in the concentrated environment.

Laboratory markets were constructed to capture the essential features of an English auction. Our purpose is not to replicate all of the circumstances that exist in actual

[3] It is worth noting that buy-orders for cattle are identical in principle to redemption value schedules used in experimental markets to induce value among buyers. See Plott, Smith (1976), and Smith (1982) for some of the early discussion on creating demand in laboratory markets.

[4] A contrasting perspective on the probable impacts of multiple buy-orders in cattle auctions is based on the premise that additional principals may submit buy-orders at an auction site. This increases the principal demand or the number of buy-orders in a particular auction for a fixed supply. Competition, therefore, among the agent buyers then may be enhanced, rather than lessened, by the need to fill these additional buy-orders. While this issue legitimately could be the focus of future study, we confine the analysis in this initial investigation to the case of a fixed principal demand shared by alternative numbers of competing agents at a single auction site. We, therefore, do not consider the case of entry of new principals in this baseline study. Such a study might allow for the interaction of agent buyers in multiple auction markets, with demand in one market increasing due to the entry of new principals, but with aggregate principal demand across markets fixed. Thus, while the principal demand in one market might increase, the principal demand in another would decrease. The results of the present study would provide the baseline comparisons for such an analysis.

livestock auctions, but to generally contribute to an understanding of behavior in English auctions that incorporated selected characteristics of livestock auctions. These included inelastic supply, relatively few regional principal processors represented by agent buyers, knowledge of quantity for sale, repeated auctions and multiple units for sale, and a design that allows the market to move toward increased concentration.

Baseline behavior was measured against adjustments or treatments to the auction environment. We compared prices when there were six agent buyers, each with one buy-order representing six homogenous principals, to a market structure in which there were two agent buyers, each with a market share of 50% representing buy-orders from three of the six homogenous principals. In these initial market settings, subjects went through a series of auction rounds that had a total of six or two buyers. Total principal demand remained constant in each treatment that was investigated. The number of units for sale in each auction round was varied randomly, but remained the same across treatments and replications.

It was of special interest to us to observe trade prices as the market *evolved* to a more concentrated state via a *buyer selection process*. The selection process was designed to retain the most successful buyers in a particular experiment throughout all auction rounds. In this experimental setting we began with six buyers, but directed the market over a series of auctions to move toward two buyers each with 50% of the buy-orders. The stylized path by which the market became more concentrated provided a glimpse into the way an evolution toward a more concentrated state can impact market prices. Finally, livestock buyers generally know the number of units available for sale at an auction site. We therefore analyzed the price effects of knowing quantity resulting from changes in agent bidding behavior associated with each of the market structures just detailed.

Buyer participants in the experiments were motivated to purchase homogenous units at the lowest possible prices, in order to receive greater monetary rewards. The behavior of agents under the alternative laboratory market environments was guided by several factors. These included the buy-order(s) or redemption value schedule(s), buyer expectations about rivals' buy-orders and bidding strategies that were revealed during the bidding process and buyer expectations about quantity available for sale when it was not known. Learning was expected to take place during the sequence of repeated auction rounds. Agents developed expectations about uncertain demand and supply relationships in the market, as well as bidding strategies of competitors. Learning also might be expected to occur differently under the alternative treatment scenarios investigated in this study resulting in different market outcomes.

Experimental Design

In one treatment there were six agent buyers who had equal market shares competing in a series of seven auction rounds for different quantities of units available for sale. This market structure was intended to represent the most competitive market among those analyzed and provided a baseline treatment. At the other extreme, a treatment was designed in which there were two agent buyers, each with buy-orders from three competing principals or 50% of the market share, competing during the sequence of seven auction rounds. Total principal demand remained the same throughout all treatments. Each buy-order represented a demand schedule, informing the agent of the maximum price at which he or she may purchase the first unit, the second unit, and so on (table 1). Individual participants in the experiments did not know explicitly the demand schedule held by other buyers in the market. When market shares were held fixed, participants were informed of the number of competing buyers in each treatment. For markets with two buyers, six subjects in a room were randomly paired for the duration of the experiment. Thus, they submitted bids without knowing the identity of the other bidder. The buy-orders were denominated in an artificial currency called tokens, which are convertible to dollars at a specified rate. Agent earnings for each unit purchased in the experiment equaled

Table 1. Buy-Order (Unit Values) Used in the Laboratory Experiment

Unit	Buy-Order (Unit Value—Tokens)
1	80
2	70
3	60
4	50
5	40
6	30
7	20
8	10

Table 2. Number of Buyers, Market Shares, Units Traded, and Predicted Equilibrium Price by Auction Round in the Experimental Design

Auction Round	No. of Buyers	Market Shares	Units Traded	Equilibrium	HHI Agents[a]
1	6[b]	1/6, 1/6, 1/6, 1/6, 1/6, 1/6	30	40	1667
2	5	2/6, 1/6, 1/6, 1/6, 1/6	23	50	2222
3	4	2/6, 2/6, 1/6, 1/6	20	50	2778
4	4	3/6, 1/6, 1/6, 1/6	20	50	3333
5	3	3/6, 2/6, 1/6	19	50	3889
6	3	4/6, 1/6, 1/6	24	50	5000
7	2[c]	3/6, 3/6	22	50	5000

[a]HHI is the Herfindahl-Hirschman Index, which is the sum of the squared market shares, expressed as percentages. An HHI less that 1000 denotes low concentration, 1000 to 1800 is moderate concentration, and greater that 1800 reflects high concentration (Federal Trade Commission and U.S. Department of Justice 2000).
[b]Six buyers compete throughout the series of seven auction rounds in a separate design.
[c]Two buyers compete throughout the series of seven auction rounds in a separate design.

the unit or buy-order value, less the price paid for the unit by the highest bidder. Participants were not permitted to purchase units for more than the redemption value.[5] Units were auctioned off one at a time and were required to be purchased in the specified order according to the buy-order schedule.

In one of our multiple-buy-order designs, across the sequence of seven auction rounds we made the market increasingly concentrated, or otherwise changed market shares, via a buyer selection process. The number of agents, their market shares, and units traded in each auction round are specifically identified in table 2. Changes in the buy-order distribution were made at the end of each auction round. In the first auction round of this design, each of the six buyers was given one-sixth of the available buy-orders, as in the treatment with six buyers throughout the seven repeated auction rounds. The least profitable buyer was determined at the completion of an auction round and was dismissed (except in rounds three and five, in which the market share distribution changed) from subsequent auction rounds. Participants were not informed why they were excused, so as not to create a tournament incentive. The available buy-order was given to a profitable buyer from the previous round. This may mimic how principals select superior agent buyers, and eventually lead to selecting the two most profitable buyers from the original six.

In the final auction round, as table 2 shows, two buyers remained, each with a market share of 50% or three of the six buy-orders. Admittedly, the path that was taken to arrive at a concentrated market with two buyers holding equal duopsony power is stylized, but it allowed us to observe the price impacts as the market became more concentrated with experienced and successful agents. The Herfindahl-Hirschman Indexes (HHI) for agents are provided in table 2 and denote the increase in market concentration as the number of buyers (agents) is reduced from six to two, evolving from 1,667 (moderate concentration) to 5,000 (high concentration).

Two other interacting influences were allowed free play in this latter design with an induced trend toward concentration. First, there was the influence that comes from repeated play itself, and as buyers were removed or the market share distribution was changed, the bidding strategies may change because the configuration of remaining bidders was altered. This results in multiple influences being measured in this design. We maintain that the influence of the buyer selection process on trade prices can be isolated by auction round seven via a comparison with results from the treatments with two and six buyers throughout the series of auction rounds.

Second, we recognize as noted above, that in English auctions for livestock the quantity for sale is typically known prior to the auction. We measured the impact of this characteristic of livestock auctions in a separate treatment. Buyers who know they can fill their buy-orders without necessarily competing for every unit offered are likely to become more strategic and, therefore, less competitive in their bidding behavior. Knowledge of quantity for sale also could aid in the strategic coordination of

[5] This precludes losses and reduces tournament incentives, i.e., where players attempt to reduce earnings of others by driving up prices and related strategic behavior.

all buyers in a bidding ring. A treatment controlling for knowledge of how many units are for sale at a single auction site was therefore warranted. A related article by the authors (Phillips, Menkhaus and Coatney) studies the formation of bidding rings in repeated English auctions and the importance of knowing quantity to a successful bidding ring.

Thirty units were brought up for sale in the first auction round, and the number was randomly set for the remaining six auction rounds (table 2). A random quantity was necessary to prevent agents from learning the exact number of units available for sale in successive auction rounds, when quantity for sale was not announced. The quantities set for each auction round remained the same across all experiments to facilitate comparisons of the results.

Finally, participants were given an opportunity to earn a bonus ($5.00) in a lottery at the end of each auction round. The bonus was awarded to enhance positive inducements for prudent pricing decisions. The chances of winning the lottery and receiving the bonus increased as more tokens were earned in the auctions. Thus, it is very similar to a commission. The probability of a subject winning the lottery was the person's share of total earnings for the round. Successful agents (based on earnings) have an expectation of being paid a bonus. The more successful they are the greater is the bonus expectation.[6]

A summary of the treatments conducted for the experimental design is referenced as: Base(N)—total quantity for sale not known and Qnt(N)—quantity for sale known; where N is the number of buyers: 6; 6–2 (progressive concentration treatment); or 2 in the respective market settings. There were therefore six separate auction environments investigated, each environment was replicated three times with different subjects participating in each. The auctioneer's starting price (40 tokens) and seller reservation price (30 tokens), remained constant throughout all experiments.[7] The seller reservation price was set lower than the auctioneer starting price so as not to directly divulge the seller reservation price to the buyers.

The competitive equilibrium price in a multiple-unit English auction is found by the intersection of market demand and supply. The market demand relationship in our experiment is depicted in figure 1. This schedule reflects the declining nature of the six buy-order schedules. The supply relationship is vertical and its position depends on the number of units available for sale in a particular auction session. From figure 1, for 19–24 units the predicted equilibrium price, given the supply and demand conditions in the experiment, is 50 tokens. This competitive equilibrium price provides a standard to which trade prices derived from the alternative treatments in our experimental design can be compared. Evidence of collusive behavior exists if trade prices are consistently lower than the predicted competitive equilibrium in a particular institutional setting prescribed in the experimental design.

Laboratory Procedures

A laboratory market session began by reading the instructions for the computerized English auction, followed by a practice session to familiarize participants with the computer screen and auction trading. Six units were traded in the practice session, using buy-order values different from those used in the actual sessions. The description of the procedures that follows is for the experimental treatments starting with six buyers and progressing to two buyers. Experiments with the same six and two buyers throughout the sequence of seven auctions were conducted in a similar manner. Unit redemption values, bid prices and earnings were denoted in an artificial currency called "tokens," which was convertible into dollars at a rate of 1 token = $0.01. (The exchange rate for experiments with six buyers during the entire sequence of seven auctions was 1 token = $0.05, because we expected total earnings to be less with sustained competition.)

Each participant's computer screen kept track of a budget, which was 300 tokens for

[6] While the bonus lottery provides additional motivation for study participants, it could result in strategic behavior. Buyers potentially could bid up the price of latter units in order to increase their chances of winning the lottery. This might be most evident in the case of the two-buyer design. If prices were consistently below the equilibrium, however, the effect of collusion would be evident, even with this price-increasing influence. Nevertheless, we conducted additional experiments to test for possible effects due to the bonus in the case of two buyers with quantity for sale known. Mean prices across units sold by replications (three) for each of the seven auction sessions were not statistically different for the bonus and no bonus treatments, as per the non-parametric Wilcoxon test.

[7] Future research could address the price impacts of varying the reservation and starting prices. In this study, however, we chose not to incorporate strategic behavior from the auctioneer. Additional research also could focus on the impact of a stronger budget restriction, which is discussed later.

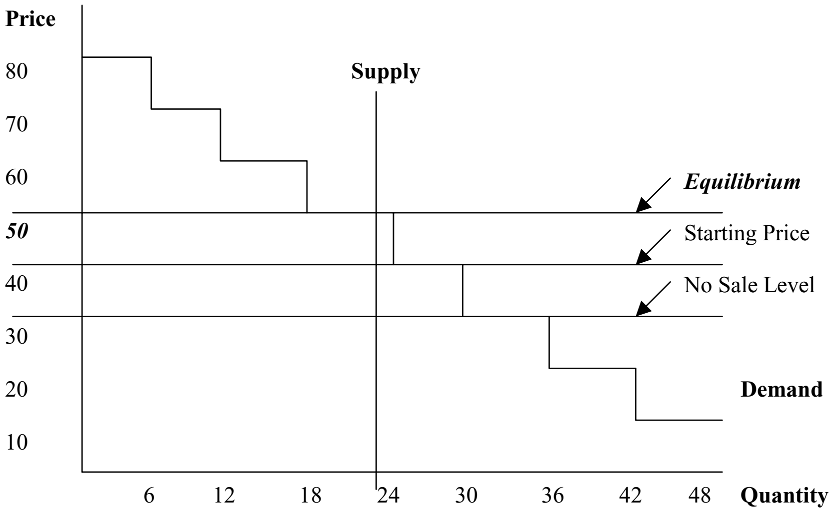

Figure 1. Market supply and demand for the laboratory experiment

each buy-order schedule during an auction round. The budget was a weak restriction in these experiments; as table 1 shows it allowed the maximum price to be paid for each of the first five units by each buyer. Buyers with multiple buy-orders were provided with an additional 300 tokens for each additional buy-order schedule they received. For example, if a player received the buy-orders from two other players, who had been excused in the 6–2 treatments, he or she would receive a budget of 900 tokens. The budget was reduced by the amount of the trade price with each purchase made by a participant. Current earnings during an auction round and accumulated earnings from all rounds were reported on a participant's computer screen, along with the buy-order schedule, price paid for each unit, and unit profits. Accumulated earnings included an initial participation fee ($10.00), profits earned during each auction round of the experiment and possible lottery winnings. Budgets were reset at the beginning of each auction round. Final payoffs to participants ranged from a low of $10.05 for individuals dismissed after the first auction round (in the six-to-two buyers case) to about $75.00 for those completing all rounds of the experiment.

The computer served as the auctioneer in this experiment. When the bidding began for an item the screen displayed "Do I have a bid for _____?" The initial bid was 40 tokens. If a buyer wanted to bid higher, he or she used the mouse to click on a bid box shown on the screen. The next bid amount went up by one token as players clicked. Typing in a bid could make bigger increases. If the participant had the high bid, the screen displayed "You have the bid," if not, it showed "The current bid is ____." When the bidding stopped, the screen flashed "going once, going twice." The computer waited for two seconds for new bids. If there were none, the unit was awarded to the highest bidder. When the sale was made the message "Sold!! The unit was sold for___tokens" or "You bought the unit for___tokens" appeared.[8] The winning bidder moved to the next lower valued unit on the redemption schedule. Those players who were not the highest bidder remained on the value of the unit for which they were bidding before the sale. If the buyers considered the initial bid too high, the auctioneer lowered the start price (40 tokens) incrementally by one token until a buyer clicked on the bid box with the mouse. If the bid decremented below 30 tokens, the unit was declared a "no sale" and buyers lost the opportunity to buy the unit.

During experiments for which the quantity to be sold was announced, the number of units available for purchase was written on the board before the auction round began. Enough units were offered in the first auction round (30 units) in order to provide ample opportunity for participants to understand the

[8] Note that the bidders and buyers are anonymous in this procedure. Anonymity of players reduces the opportunity for creating bidding rings and stimulates a competitive market atmosphere. We believe that this procedure, although at odds with some real-world English auctions, provides a more valid control treatment to which to compare results from our test treatments. Anonymity, of course, was not maintained when there were only two competing buyers.

bidding process. The competitive equilibrium price at this level of units offered for sale is 40 tokens, 10 tokens less than in subsequent auction rounds (figure 1).[9]

Analysis of Data

Trade prices were the main data of interest generated from the experiments. A convergence model that assumes price (the dependent variable) for each treatment originates from a starting level and then converges to an asymptote level is specified (Noussair, Plott, and Riezman).[10] The primary purpose of this dynamic model is to test if prices for units traded in alternative treatments during each auction round converge to levels statistically different from those predicted by the competitive model, at the intersection of the experimental supply and demand schedules. This model also provides a means to test for differences in price convergence levels between alternative treatments, as well as isolate trends in prices across units traded in an auction round for each treatment.

Prices from the alternative treatments, including the competitive equilibrium that served as the base treatment, over several time periods (units traded) create a cross-sectional time series. These data may be serially correlated and heteroscedastic. Data also may be contemporaneously correlated between treatments. A primary source of contemporaneous correlation is due to the same unit values being used from one treatment to the next. We estimated the following general convergence model for each auction round

$$P_{it} = B_0(1/t) + B_1[(t-1)/t] + \sum_{j=1}^{i-1} \alpha_j D_j(1/t) + \sum_{j=1}^{i-1} \Gamma_j D_j[(t-1)/t] + u_{it}$$

where: P_{it} = average sale price for each treatment (Base(N), Qnt(N), and the baseline competitive equilibrium each constituting treatment i across the three replications for each of t units in an auction round; B_0 = the predicted starting level for the base category; B_1 = the predicted asymptote for price in the base category; t = units sold in an auction round; D_j = a dummy variable representing the jth treatment; α_j and Γ_j = the regression parameters associated with the D_j starting level and asymptote shifters, respectively; and u_{it} = error term.

The Parks statistical method was used to estimate the price dependent model for each auction round. This is an autoregressive model in which the random errors $u_{it}, i = 1, 2, \ldots, j, t = 1, \ldots$ units traded, have the structures (SAS); $E(u_{it}^2) = \sigma_{ii}$ (heteroscedasticity), $E(u_{it}, u_{jt}) = \sigma_{ij}$ (contemporaneously correlated), and $u_{it} = \rho_i u_{i,t-1} + \varepsilon_{it}$ (autocorrelation). The Parks method assumes a first-order autoregressive error structure with contemporaneous correlation between cross sections. The covariance matrix is obtained by a two-stage procedure leading to the estimation of model regression parameters by generalized least squares. (See SAS, pp. 882–884, for details of this estimation method.) The use of the Parks method allowed us to take account of the unique statistical problems resulting from the panel data sets that consist of time series observations on each of the cross-sectional units generated in our experiments. This method, however, requires that the number of cross sections be less than the number of time series observations, precluding the pooling of auction round and treatment data. Pairwise tests of estimated starting level or asymptote parameters across treatments also were conducted for auction round seven.

Results and Discussion

A consistent downward trend in price through the successive auction rounds, based on the estimated starting levels and asymptotes from the convergence model (table 3), is evident in the Base(6–2) treatment. Starting trade prices begin at 22.70 tokens above the predicted competitive price in round 1, while in round 7, prices are beginning 4.43 tokens below the competitive level. Similarly, the asymptotes are 10.23 tokens higher than the competitive prediction in round 1, but 13.05 tokens below the competitive level in round 7. These trends

[9] A lower equilibrium price in the first auction round could lead to lower price expectations and lower prices during subsequent auction rounds. This design feature, based on the results, did not have a price suppressive effect in subsequent rounds, because competitive prices were observed in some treatments. Future work, however, should consider maintaining a constant equilibrium price across auction rounds.

[10] Statistical tests of differences in treatment means are problematic. Mean prices are not independent across auction sessions. Within an auction session only the replication means are independent, but the normality assumption almost certainly is not met, given that there are only three replications.

Table 3. Estimated Convergence Models—Auction Rounds 1–7, Competitive Equilibrium is the Base

	Starting Levels: Estimated Parameters (Standard Errors)						
Treatment	Auction Round 1	Auction Round 2	Auction Round 3	Auction Round 4	Auction Round 5	Auction Round 6	Auction Round 7
Competitive Equilibrium	40.00*	50.00*	50.00*	50.00*	50.00*	50.00*	50.00*
Base (6–2)	22.70*	15.09*	7.73*	5.32	1.07	−7.16*	−4.43*
	(5.25)	(4.27)	(2.81)	(2.17)	(1.69)	(2.00)	(1.34)
Base (6)	18.97*	14.03*	13.34*	12.88*	15.43*	7.65*	6.45*
	(5.27)	(4.18)	(3.53)	(2.99)	(2.15)	(2.23)	(2.44)
Base (2)	17.32	5.99	1.42	−0.04	13.04*	1.83	5.07
	(8.70)	(6.12)	(6.50)	(5.81)	(4.69)	(5.01)	(5.26)
Qnt (6–2)	19.24*	9.19*	5.23	−1.81	−5.35*	−1.45	−6.90*
	(4.87)	(3.28)	(2.20)	(1.10)	(0.71)	(1.80)	(1.60)
Qnt (6)	24.41*	10.19*	8.52*	9.36*	11.70*	2.87	5.15*
	(5.06)	(3.49)	(2.87)	(1.45)	(1.26)	(2.43)	(1.54)
Qnt (2)	−5.44	−17.87*	−13.57*	−19.18*	−12.32*	−11.04*	−10.04*
	(4.49)	(2.24)	(1.65)	(1.72)	(1.80)	(1.10)	(1.46)
	Asymptotes: Estimated Parameters (Standard Errors)						
Competitive Equilibrium	40.00*	50.00*	50.00*	50.00*	50.00*	50.00*	50.00*
Base (6–2)	10.23*	−0.25	−5.19	−8.21*	−9.96*	−12.56*	−13.05*
	(3.90)	(3.20)	(2.23)	(1.33)	(1.25)	(1.32)	(1.04)
Base (6)	8.50	−3.66	−1.99	−3.81	−2.70	−4.45*	−4.44
	(3.60)	(3.16)	(2.57)	(2.36)	(1.45)	(1.55)	(1.71)
Base (2)	7.49	−2.24	1.67	1.85	2.11	−1.49	−4.65
	(5.10)	(4.20)	(3.42)	(2.49)	(2.15)	(2.87)	(2.55)
Qnt (6–2)	6.81	−1.18	−4.78*	−4.92*	−5.46*	−7.94*	−10.31*
	(3.80)	(1.84)	(1.09)	(0.41)	(0.33)	(0.68)	(0.75)
Qnt (6)	6.68	−0.96	0.65	−0.39	1.86*	−3.08	2.50*
	(3.57)	(1.57)	(1.85)	(0.66)	(0.59)	(1.63)	(0.72)
Qnt (2)	−1.35	−14.85*	−14.70*	−10.88*	−9.73*	−10.58*	−12.25*
	(1.88)	(1.74)	(0.79)	(0.58)	(1.53)	(0.54)	(0.47)
R-Square	0.99	0.99	0.99	0.99	0.99	0.99	0.99

*Indicates regression parameter is significantly different from zero, $\alpha = 0.001$.

can be attributed to the combined influences of learning in repeated play, changes in market concentration and selectively choosing the most successful buyers during the sequence of auction rounds. Prices converge to levels significantly below the competitive equilibrium in the Base(6–2) treatment by auction round four, in which one buyer has three buy-orders; and they converge to significantly lower levels in subsequent auction rounds, each of which exhibits a higher HHI up to 5,000.

This pricing pattern contrasts with that in the Base(6) and Base(2) treatments, where the estimated asymptotes generally are not significantly different from the predicted competitive equilibrium level through the seven auction rounds. By auction round seven there is no difference in either the starting levels or asymptotes between the Base(6) and Base(2) treatments (table 4). We conclude that increased market concentration resulting from multiple-buy-orders in our laboratory English auctions by itself was unable to reduce price below the competitive equilibrium. Price levels are consistent with the competitive prediction in the Base(6) and Base(2) treatments. The *evolution* toward concentration, rather than the repeated play of agents, contributes most to prices converging to a level substantially below (26%) the competitive equilibrium.

Are these results robust to agents gaining information about supply? Suppose bidders are told the number of units that are available in an auction round. Prices in the Qnt(6–2) and Base(6–2) treatments exhibit convergence levels significantly below the competitive equilibrium by auction rounds three and four, respectively, and thereafter (table 3), but the impact of knowing quantity is not significantly different from when quantity is unknown (table 4).

Table 4. Pairwise Comparisons of Starting Levels and Asymptotes by Treatment, *F*-Values, Auction Round 7

	Starting Levels				
	Base (6–2)	Base (6)	Base (2)	Qnt (6–2)	Qnt (6)
Base (6)	25.79*				
Base (2)	3.76	0.10			
Qnt (6–2)	1.38	25.35*	4.84		
Qnt (6)	40.14*	0.43	0.00	48.66*	
Qnt (2)	9.34*	34.81*	7.98*	1.88	55.22*
			Asymptotes		
Base (6)	33.43*				
Base (2)	12.75*	0.01			
Qnt (6–2)	4.46	11.48*	4.63		
Qnt (6)	119.76*	1.86	0.83	92.67*	
Qnt (2)	0.55	19.79*	8.85*	4.29	139.97*

*Indicates pairwise difference is significantly different from zero, $\alpha = 0.001$

Convergence levels across the seven auction rounds in the case of six buyers, when quantity for sale is known [Qnt(6)], are not consistently and significantly different from the competitive equilibrium level, a result that is similar to the Base(6) treatment. In auction round seven, in fact, there is no difference in the starting levels or asymptotes between the Base(6) and Qnt(6) treatments (table 4). Knowledge of quantity for sale when buy orders are equally distributed among six buyers [Qnt(6)] does not greatly impact prices, as compared to when there are six buyers without supply information.

The equal distribution of buy-orders between two buyers, combined with announcing quantity for sale [Qnt(2)], in contrast, is a powerful price depressant in our laboratory markets. Starting levels and asymptotes are consistently and significantly below the competitive level across the auction rounds for the Qnt(2) treatment (table 3). The convergence level for price in auction round seven is significantly lower in Qnt(2) than in the Qnt(6) treatment (table 4). Now the evolution toward greater concentration in the market does not appear to contribute to additional price depression. Comparing the Qnt(6–2) and Qnt(2) treatments in the final auction round, we observe respective trade prices 10.31 and 12.25 tokens below the competitive prediction, and there is no difference in these asymptotes as reported in table 4.

Across all auction rounds, prices converge to levels that are generally more competitive for the Base(6), Base(2) and Qnt(6) treatments and less competitive for the Base(6–2), Qnt(6–2) and Qnt(2) treatments (table 3). The effects of selectively concentrating successful buyers through a sequence of auctions and allowing a duopsony structured market the advantage of knowing quantity of units for sale prior to the auction are the most influential facilitating influences contributing to lower than predicted prices in the laboratory English auctions conducted in this study. Separately, these treatments seem to have about the same impact, and the influences combined in Qnt(6–2) do not cause further price reductions.

A comparison of the estimated starting level and asymptote within and across auction rounds can be used to assess the stability of prices. The typical pattern is for the price to start below the competitive prediction in latter rounds of the Base(6–2) and Qnt(6–2) treatments and in Qnt(2) and to remain below, or trend downward from, this level for all units traded during the auction round. This result differs from that observed in English auction experiments reported by Plott some years ago. Plott found that prices generally converged from above toward the competitive equilibrium, and the distribution of income tended to favor the passive side of the market, i.e., the side of the market not bidding, in this case sellers in livestock auctions. Cooperative activity between/among buyers is present in the Base(6–2), Qnt(6–2), and Qnt(2) market environments, resulting in reduced prices for sellers. On the other hand, trade prices in the Base(6), Base(2), and Qnt(6) treatments begin above competitive equilibrium level and converge to or near this level, which is in line with the results reported by Plott.

Summary and Conclusions

The use of shared agent buyers with multiple buy-orders from several packer-principals has resulted in increased market concentration at livestock auctions. The primary focus of this study has been to identify the price impacts of this practice. An important point of this study has been to observe the dynamics of cooperation as the market becomes more concentrated. A laboratory approach was used to maintain control and to specifically sort out the price impacts across selected treatments. The laboratory markets were structured to capture the basic features of an English auction. It was not the intent to replicate all the complexities of a field environment. Instead, simple changes in the basic environment were made via experiment treatments to observe the resulting price impacts. These alternative laboratory environments provided the data for analysis.

Base treatments in which quantities for sale were not announced were conducted utilizing the same six buyers and two buyers throughout a sequence of seven auctions sessions. An additional treatment also was conducted by selectively choosing the buyer(s) with the most earnings in the preceding auction session to receive an additional buy-order. This treatment began with six buyers and ended with two buyers. Announcing quantity for sale before the auction session began resulted in another set of three treatments. There were, therefore, six treatments in the experimental design. Three replications of each treatment provided the data for the analyses. Total principal demand remained constant in each treatment that was investigated. We therefore, did not consider the case in which demand, and competition among agent buyers, at a particular auction might increase, as a result of multiple-buy-orders expanding the number of principals represented by agents in a specific market.

A summary of the laboratory results is captured in five key points: (*a*) Six buyers with equal buy-orders produced competitive prices when quantity for sale was known or not known. (*b*) Buy-orders equally distributed between two buyers and six buyers when quantity for sale was *not* known resulted in prices that were competitive and not statistically different. (*c*) An evolution of concentration that left the most successful buyers in a sequence of auction sessions, depressed price to levels about 26% below the competitive prediction. (*d*) An equal distribution of buy-orders between two buyers when sale quantities were known resulted in prices significantly lower than the predicted competitive price. (*e*) Allowing the market to become more concentrated during a series of auctions impacted prices to about the same degree as when the same two buyers participated throughout the sequence of auctions and knew quantity for sale.

The provision of multiple-buy-orders by competing principals to the same agent-buyer increases concentration in an auction market. Concentration, although a central issue related to market structures, may not be the sole indicator of whether or not a market generates less than competitive prices. As seen in the results from our experiments, in the base treatment, competitive equilibrium is reached with both six and two buyers. This result, however, is not robust to a known supply quantity, as two buyers are able to coordinate on significantly lower prices. It is further not robust to the structure of a concentrating market; progressively concentrated agents reach prices significantly below equilibrium. Since quantities in many naturally occurring auctions are known, there exists a 'facilitating influence' toward collusion in current English auction practices. The historical process of increased concentration among agent-buyers may further help this collusion. These results provide evidence consistent with the concerns raised by livestock sellers and auction market owners of the use of shared agents in already concentrated markets.

[Received July 2001; accepted December 2002.]

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